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To Mr. O. Bernaus
Manager
Civil Maintenance Department
Hydraulic Generation & Transmission Operations Division

Attn: Mr. G.F. Smith/Mr. R. Boothby

DEFORMATION MONITORING AT G.W. RAYNER GS

R.H.K. Tsang

A field program to improve deformation monitoring at G.W. Rayner GS was implemented. Two survey monuments with force centering plates were installed. Four normal pendulums were inspected and maintenance/cleaning was performed. Three additional brass survey plugs were installed along the dam crest. Installation of an invar wire and pins at pendulum 3+93 was completed. These measures will improve the monitoring program, as well as confirm anomalous data previously collected.

1.0 INTRODUCTION

At the request of Dam Safety (memo dated May 15, 1991), the following work was performed at G.W. Rayner GS:

(a) Installation of two survey monuments with forced centering plates.

(b) Inspection and maintenance of four normal pendulums and shafts.

(c) Installation of one invar wire and pin for the pendulum at chainage 3+93.

This report documents the installation, inspection, and maintenance work performed during July 12 to 19, 1991 by the Soil Sciences Section, Civil Research Department. The details of the equipment suppliers are contained in Appendix A.

job	file	date	report no.
43-136-281	843.12	September 25, 1991	91-209-K

92-04549/

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2.0 SURVEY MONUMENTS INSTALLATION

Two survey monuments with forced centering plates were installed at the locations shown in Figures 1 and 2. The two survey monuments were anchored to bedrock. These two "off-dam" survey monuments will serve as the "off-dam" reference points off-site for the brass survey plugs along the dam crest. The two monuments are aligned with the existing brass plugs but do not obstruct access across the dam. The monuments were constructed as per Civil Works specifications (Appendix A). Figure 3 shows the typical formwork required and the completed survey monument.

At the west end of the dam, the monument was installed with anchors extending through the concrete and anchored approximately 5 to 10 cm into bedrock. The total anchor length in concrete and rock was 0.92 m (3 ft). The monument height above ground was 1.37 m (4-1/2 ft).

At the east end of the dam about 0.76 m (2-1/2 ft) of gravel and rubble was excavated by a backhoe to expose the bedrock. The monument was anchored 0.61 m (2 ft) in sound, competent bedrock. The total monument height was 1.83 m (6 ft) and the excavation was backfilled to the original grade, leaving about 1.22 m (4 ft) stick-up.

2.1 Additional Brass Survey Plugs Installed

Three additional brass plugs were installed along the dam crest (Figure 4). The brass plugs will be monitored for movements along the dam crest. Two of these plugs were installed adjacent to the pendulums at 3+47 and 7+02 to serve as a reference for any movements indicated by these pendulums. The other plug was installed near the log chute to close a gap in the survey line. The location of the plugs with respect to the survey monuments are shown in Figure 1.

3.0 INSPECTION AND MAINTENANCE OF NORMAL PENDULUMS

An inspection of the four pendulums was completed (Figure 5). The inspection was performed to validate the data collected by Dam Safety between February to April, 1988. Figures 7 to 10 indicate a significant "jump" in the data collected in early 1988 for four normal pendulums, 3+47, 3+93, 5+68, and 7+02. An upstream drift in the vicinity of pendulum 3+47 was also observed. The protective covers were removed on the deck and resealed.

The details of the inspection for each respective normal pendulum are contained in Appendix B. All four pendulums inspected were in good condition and required minimal cleaning of the hardware. All the pendulums were relatively dry. Periodic cleaning of hardware is required.

A broken wire suspension bar at 3+93 may be the source of the data shift observed in February, 1988 (Figure 6). However, the anomalous readings were observed on the other pendulums as well (Figures 7 to 10).

4.0 INVAR WIRE INSTALLATION AT 3+93

An invar wire was installed at 3+93 and extends from the deck level to the lower tunnel readout station (Figure 11). It is a standard installation requiring measurements with a depth micrometer. The measurements are taken by measuring from the reading table to a ball bearing surface attached to the invar wire.

Site personnel were instructed as to the measurement technique by Mr. A. Morton, Soil Sciences Section, Civil Research Department.

During readings of the pendulums, the depth micrometer on site was very stiff in operation. It appeared the micrometer level was bent. The micrometer should be replaced with a new MITUTOYO 0 to 4 inch range, Model 229-131, available from Atlas Machinery Supply Ltd, Toronto.

5.0 SUMMARY

A field program at G.W. Rayner GS was carried out during July 12-19, 1991 to improve deformation monitoring.

The installation of two "off-dam" survey monuments will serve as reference points for alignment and levelling surveys. Routine inspection and maintenance of the four normal pendulums was performed. A new depth micrometer is recommended to be purchased. The invar wire installation on 3+93 will provide vertical deformation data at the site. A damaged suspension bar was found at 3+93. No apparent cause for the anomalous readings observed in February and April, 1988 was determined.

ACKNOWLEDGMENTS

The cooperation and assistance from the various groups involved was appreciated.

1. Mr. A. Morton and Mr. B. Mackey, Soil Sciences Section, Civil Research Department for performing the installation, inspection, and maintenance.

2. Mr. R. Boothby, Dam Safety, Civil Maintenance Department, for arranging and coordinating the tasks.

3. Mr. M. Kovach, Geotechnical Projects Section, Civil Maintenance Department, for providing the locations and stakeout.

4. Regional staff at G.W. Rayner GS for assisting with the work program.

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Soil Sciences Section

RHKT:LM

REFERENCES

1. Memorandum to Mr. T.J. Carmichael, Soil Sciences Section, Civil Research Department, from Mr. G.F. Smith, Dam Safety, Civil Maintenance Department, dated May 15, 1991, File No DSP 410-1-38.0331.

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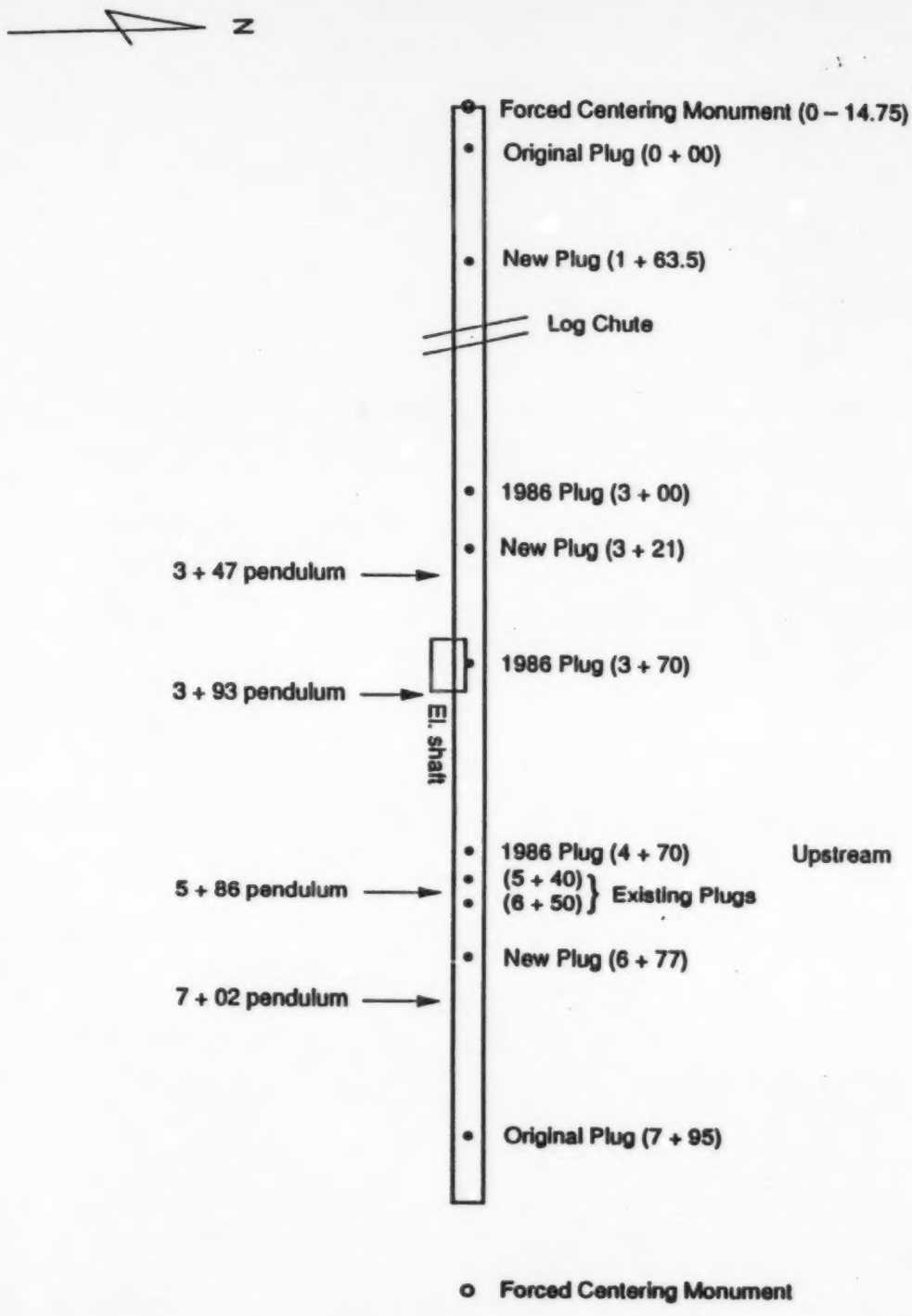


FIGURE 1

G.W. RAYNER G.S.
SURVEY MONUMENTS & BRASS PLUGS
INSTALLED JULY 9 TO 11/91

(Note: All Chainages Subject to Verification)

Not to Scale

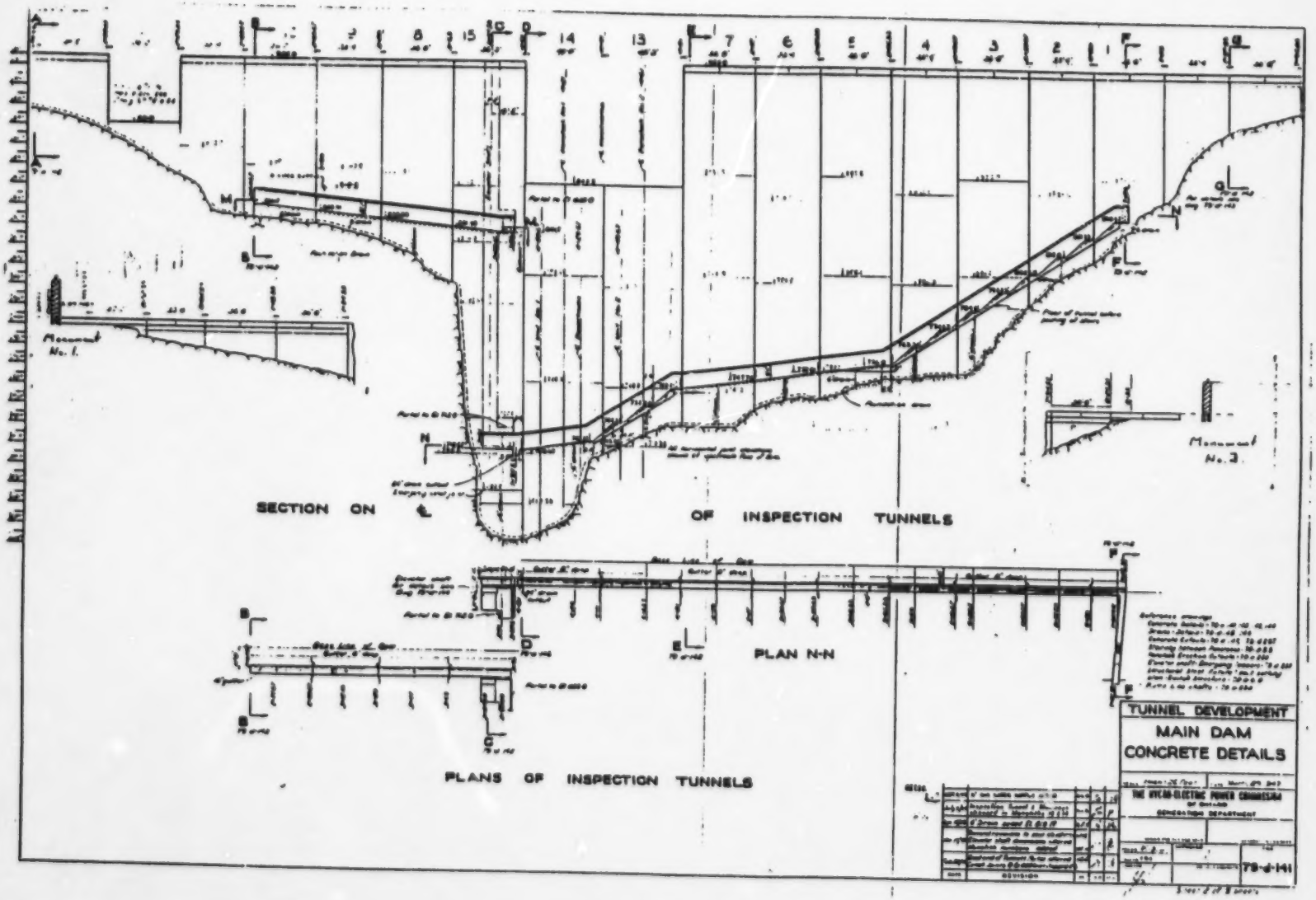
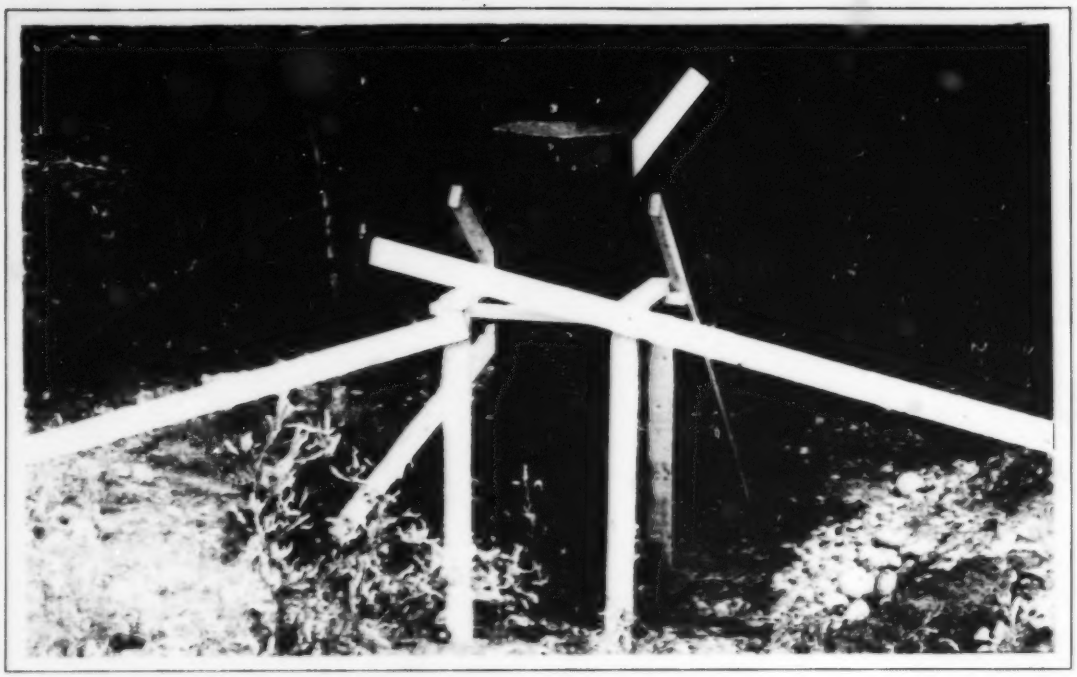


FIGURE 2
CROSS-SECTION OF MAIN DAM
DRAWING NO. 79-D-141



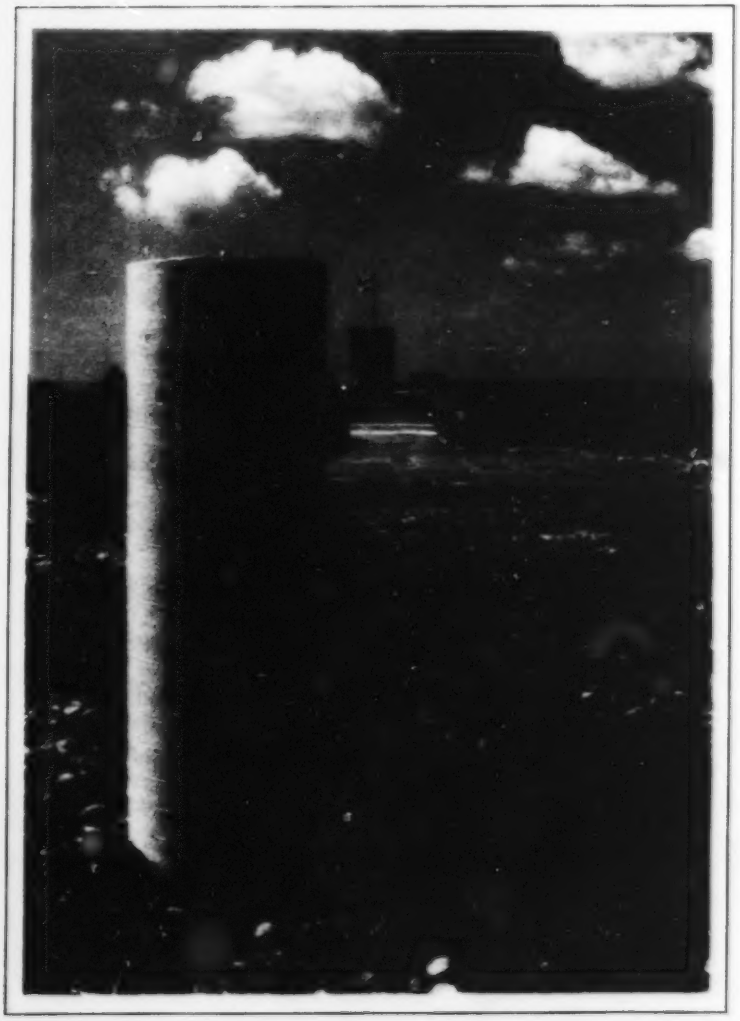


FIGURE 3

TYPICAL FORCE CENTERING PLATE AND SURVEY MONUMENT ANCHORED TO BEDROCK

(East end)

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188646-B39-RD

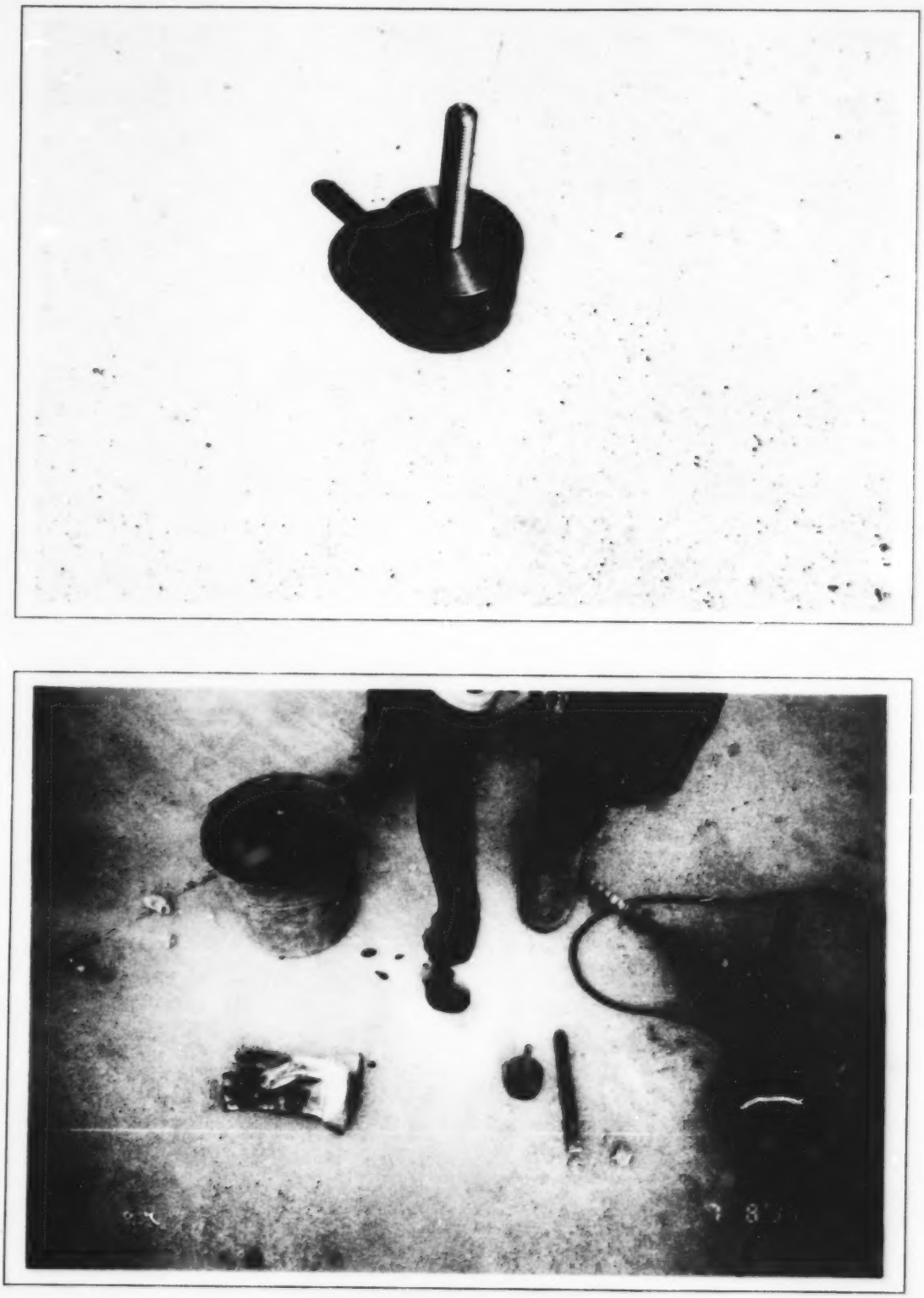
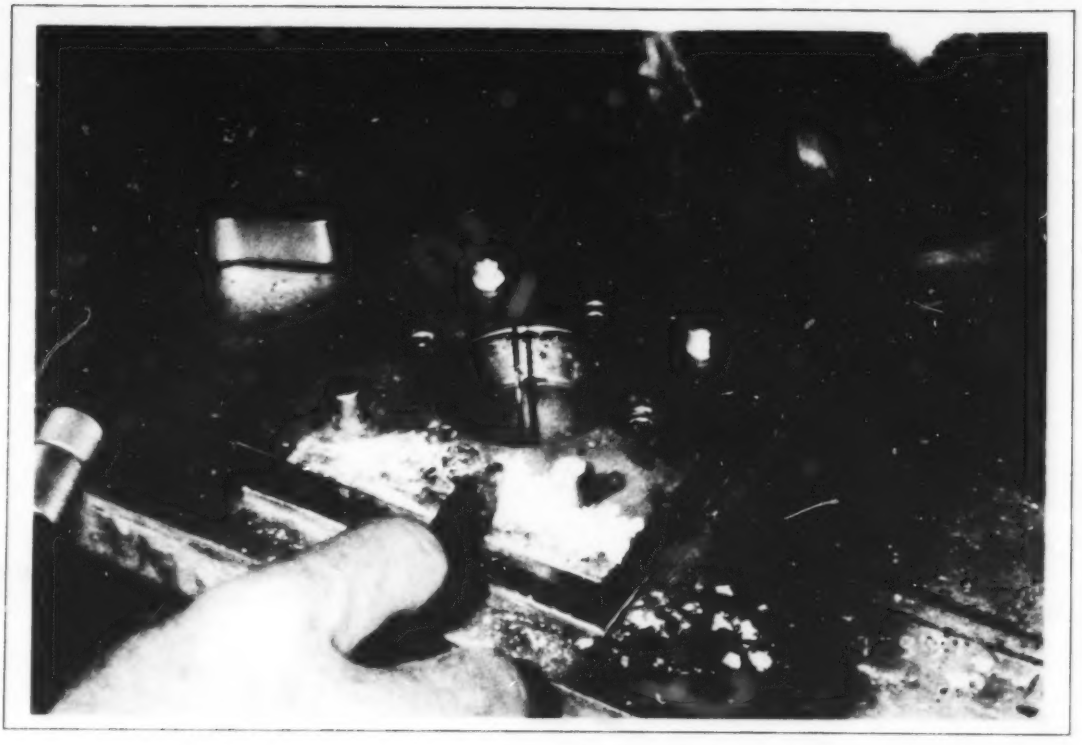


FIGURE 4

TYPICAL BRASS SURVEY PLUG INSTALLED ALONG DAM CREST



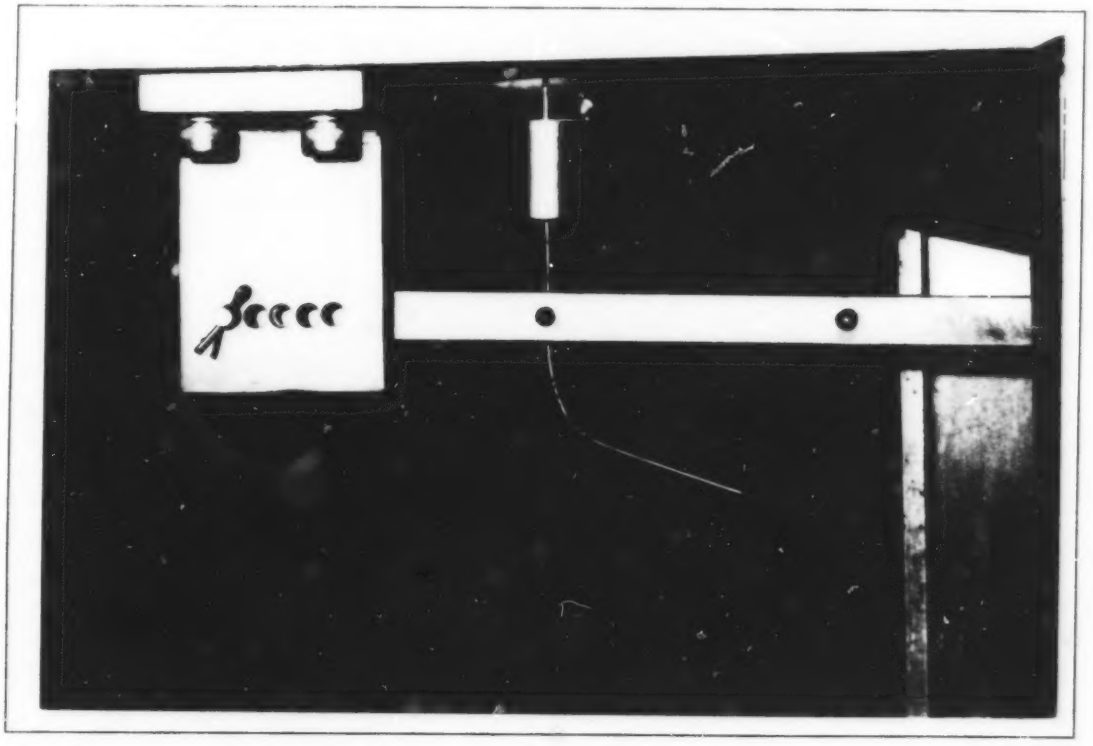


FIGURE 5

PENDULUM TABLE MAINTENANCE AND INSPECTION WAS PERFORMED

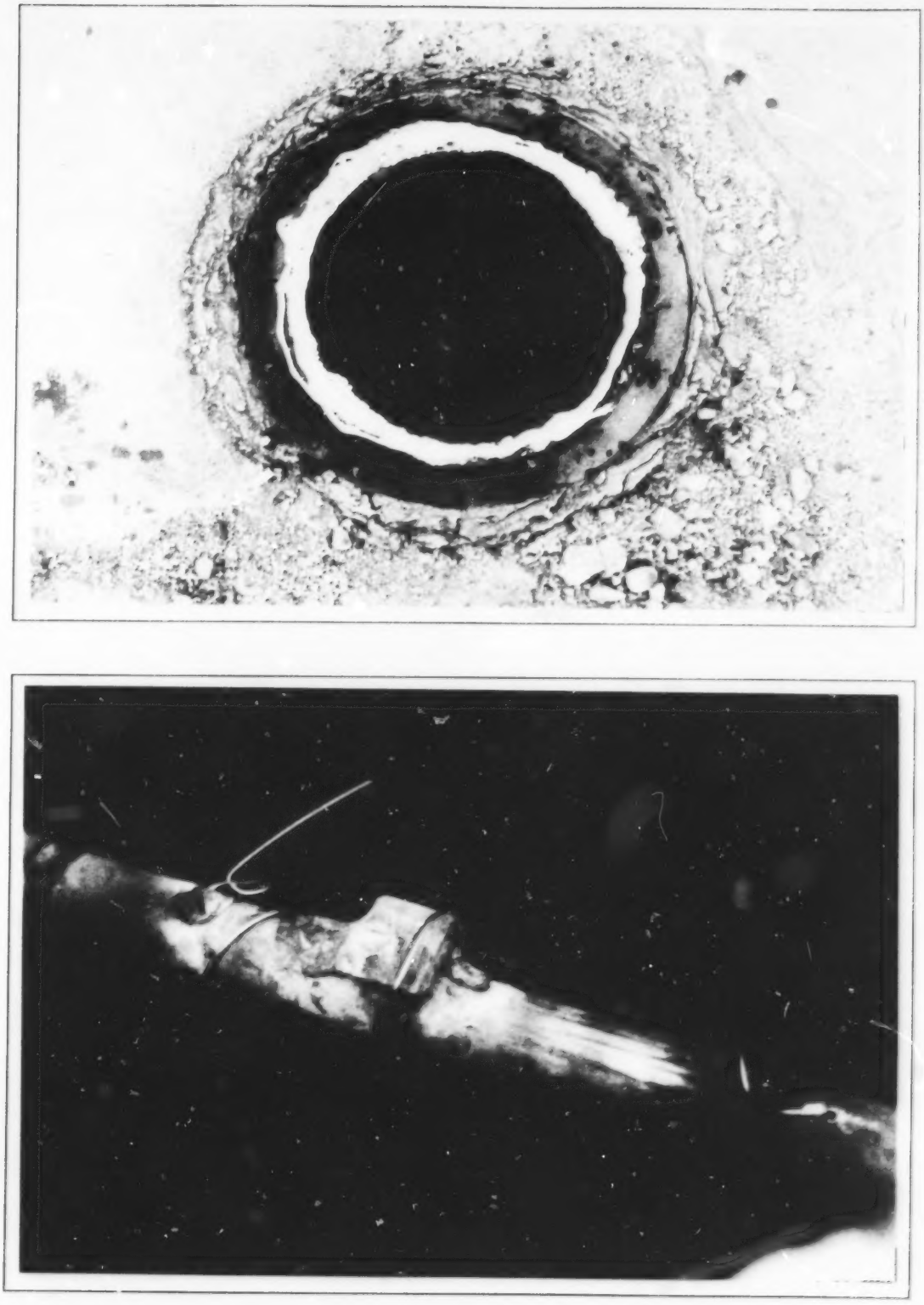


FIGURE 6

CRACKING OF SUSPENSION BAR NOTED AT NORMAL PENDULUM (3+93)
ATTACHMENT OF INVAR AND NORMAL PENDULUM WIRE CAN BE SEEN

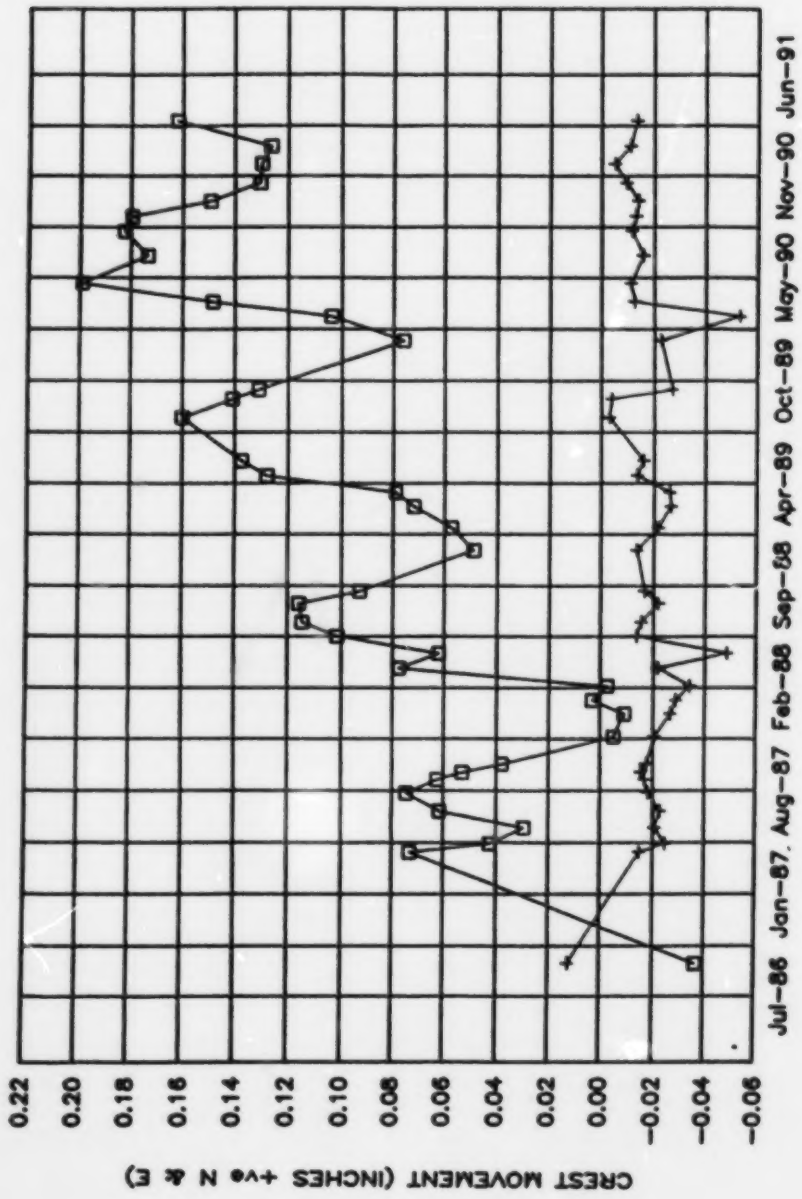


FIGURE 7
RAYNER GS - PENDULUM READINGS
CHAINAGE 3+47

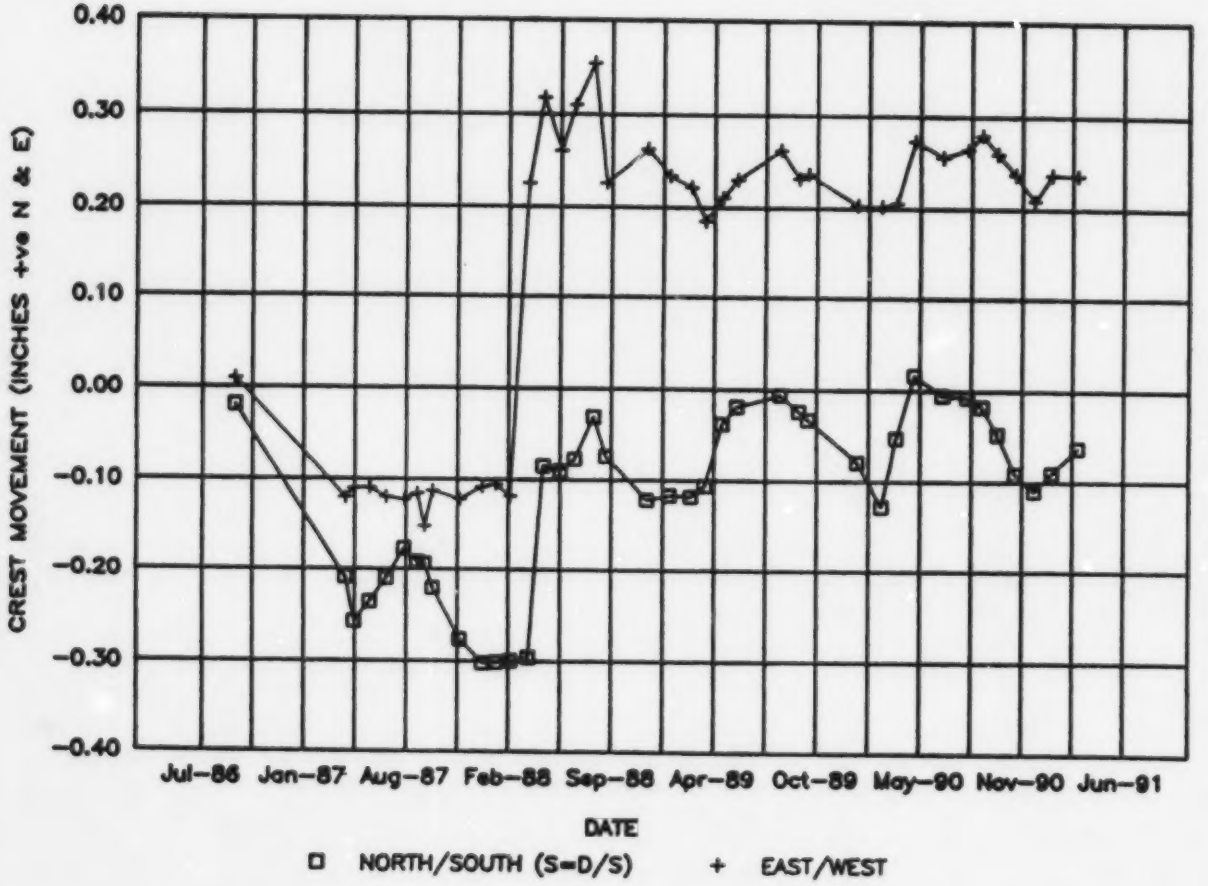


FIGURE 8
RAYNER GS - PENDULUM READINGS
CHAINAGE 3+93

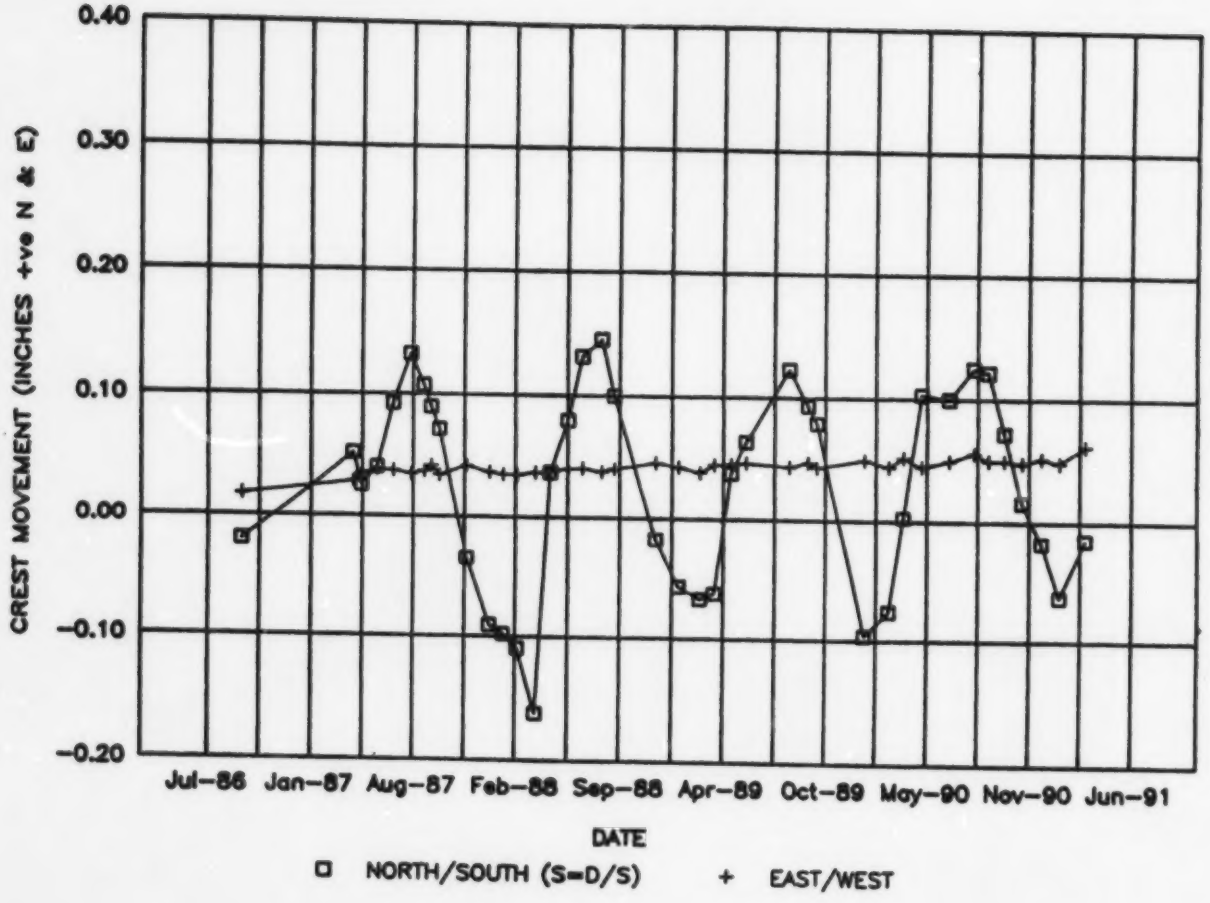


FIGURE 9
RAYNER GS - PENDULUM READINGS
CHAINAGE 5+68

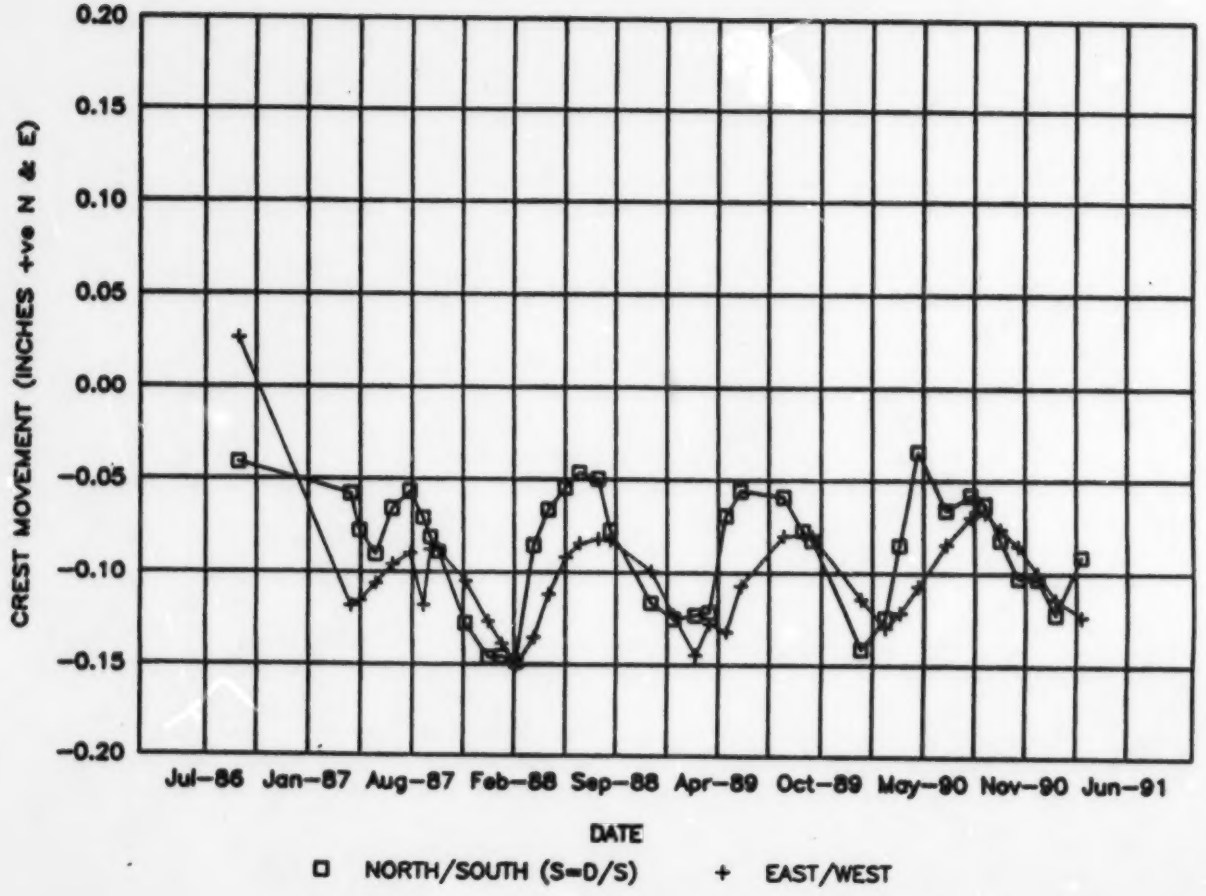


FIGURE 10

RAYNER GS - PENDULUM READINGS
CHAINAGE 7+02

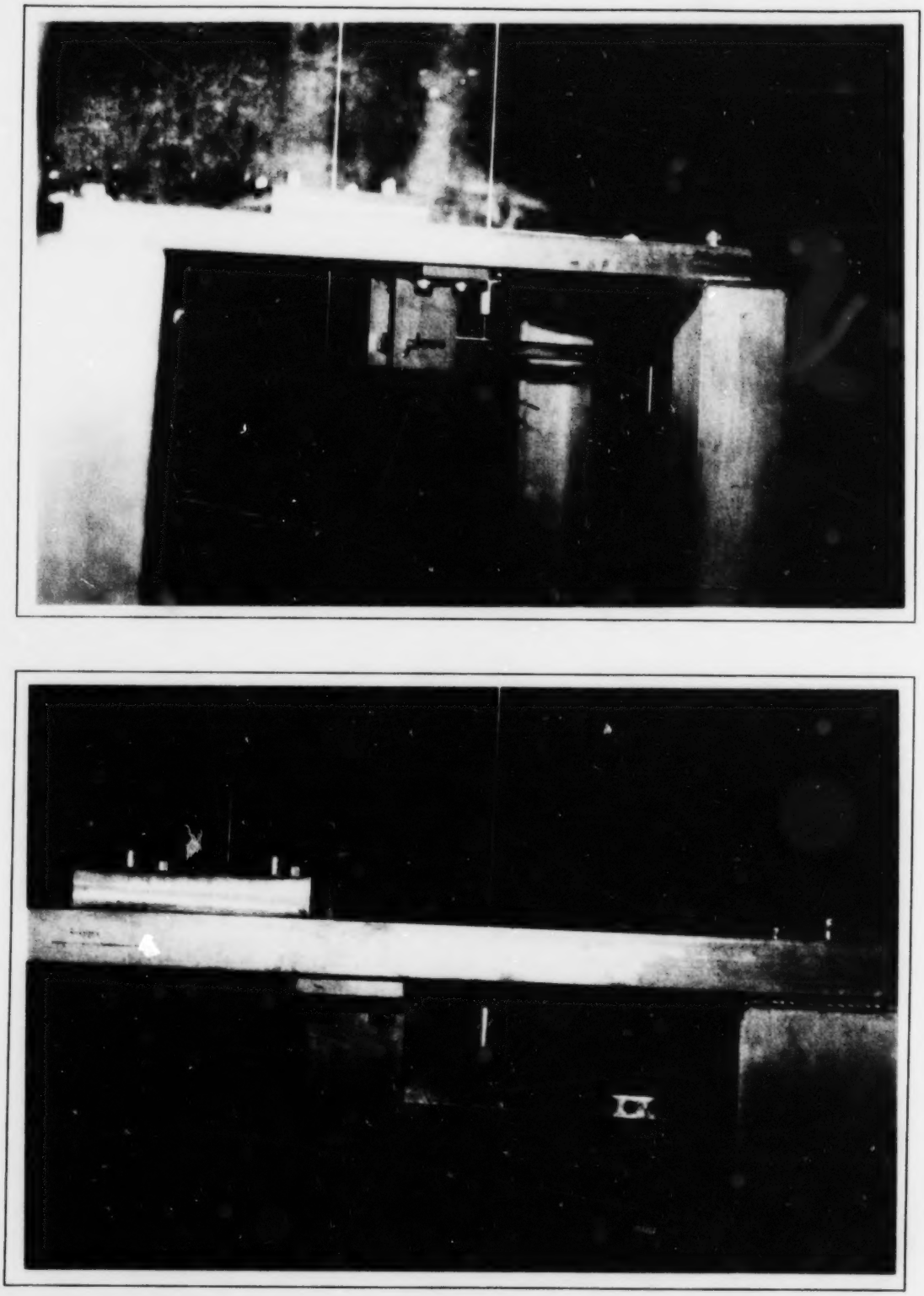


FIGURE 11

INVAR WIRE INSTALLATION WITH NORMAL PENDULUM (3+93)

APPENDIX A

Specifications for Survey Monuments

Construction of Survey Monuments

Relocation may be necessary to maintain full accessibility across the dam.

Each monument is to be constructed as indicated in Figure A1.

- Five equally spaced holes are to be drilled 3' deep into concrete or bedrock.
- 7' 3" of #6 rebar is to be grouted into each hole.
- The main portion of the pillar is to be constructed of 2500 psi concrete with 6% air entrainment. The concrete is to be poured free of cold joints.
- The pillar is to be 18" in diameter and 4' 0" high (measured from the concrete deck or bedrock surface).
- 6" of non-shrink grout is to be placed on top of the concrete, making the total height of the monument 4' 6" as measured from the concrete deck or bedrock surface).
- On the top of each monument, an instrument mounting baseplate is to be installed (see Figure A2). The plate is to be constructed entirely of stainless steel material. It is to be 9" in diameter with a 5/8" stainless steel bolt (national coarse thread) extending from the centre. A cap nut is to be installed over the bolt for protection. The plate is to be anchored to the monument using three legs welded to the bottom of the plate.
- The monuments are to have the contact between the concrete pillar and the dam crest or the concrete pillar and the bedrock surface caulked with silicone sealant.

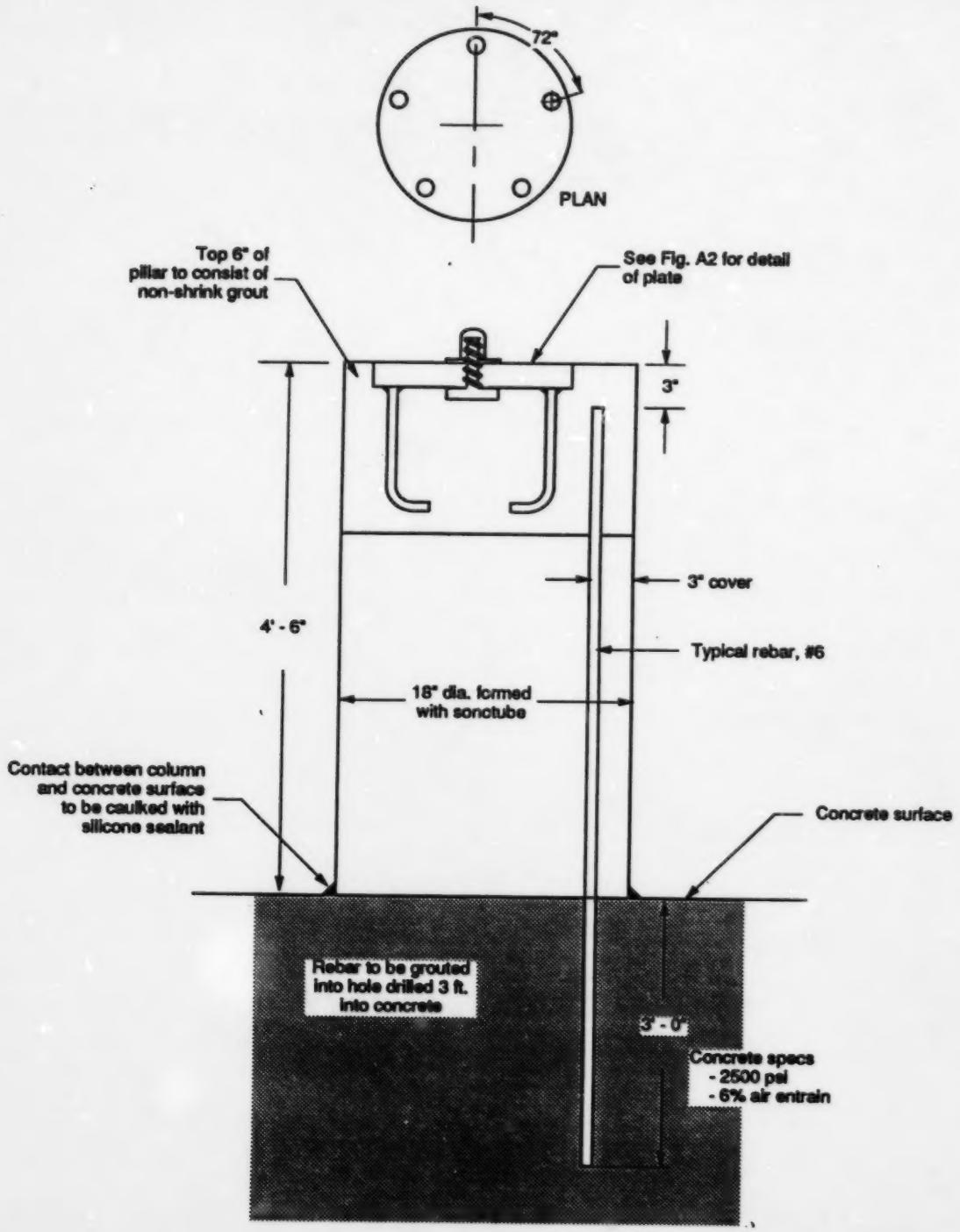

72°
PLAN
Top 6" of pillar to consist of non-shrink grout
See Fig. A2 for detail of plate
3"
3" cover
4' - 6"
Typical rebar, #6
18" dia. formed with sonotube
Contact between column and concrete surface to be caulked with silicone sealant
Concrete surface
Rebar to be grouted into hole drilled 3 ft. into concrete
3' - 0"
Concrete specs
- 2500 psi
- 6% air entrain

FIGURE A1

SKETCH OF SURVEY CONTROL MONUMENT

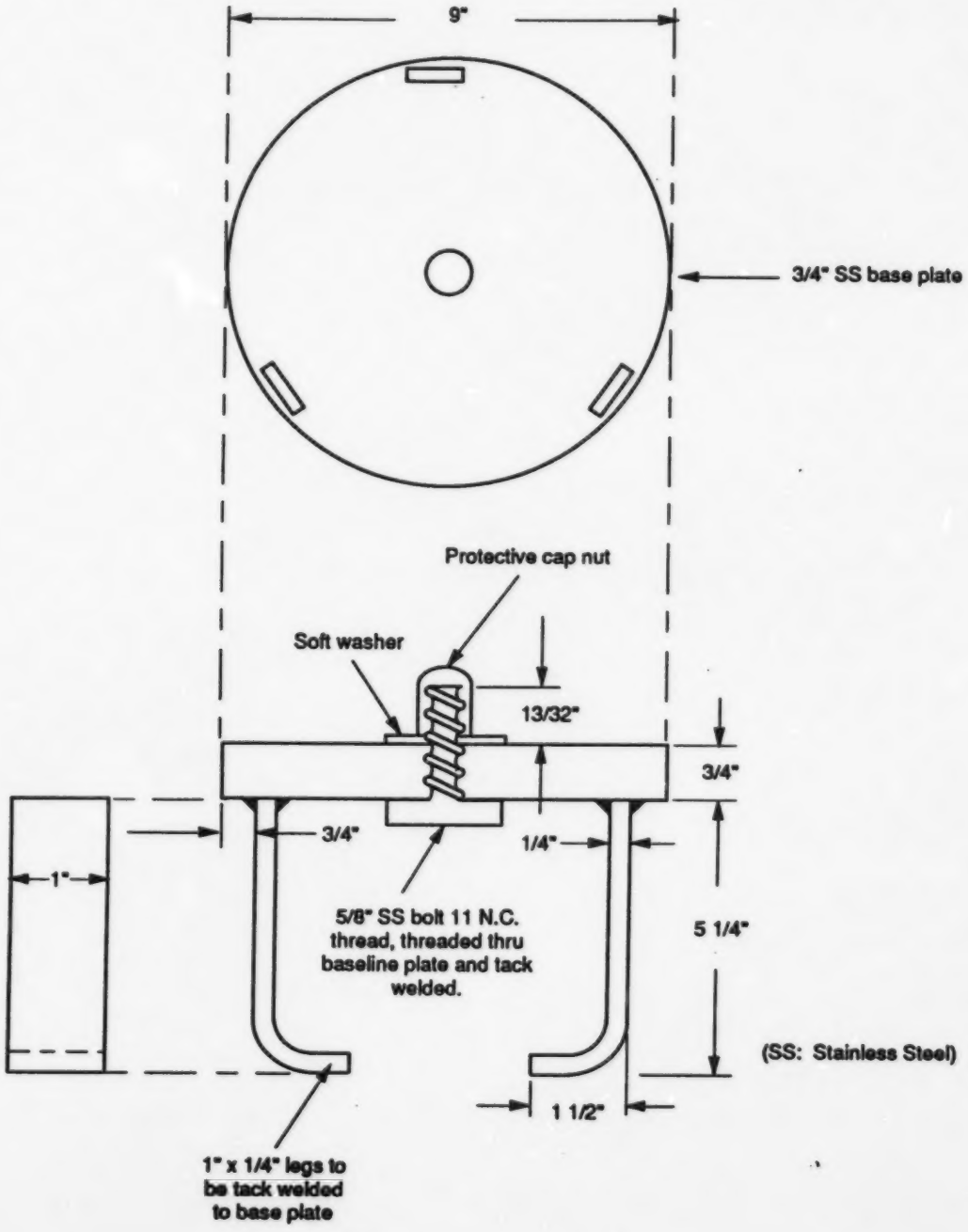


FIGURE A2

BASE PLATE

List of Equipment Suppliers

Equipment

Concrete - Ready-mix from Permanent Concrete

Hammer and bits - Service Rental and Sales

Compressor - provided by District

Backhoe - Roger Coventry Excavating

APPENDIX B

Normal Pendulum Inspection

Forward to: Supervisor
Dam Safety Program
Civil Works Department, A12-H14

Recorded by A. Morton

refer to

Structure Rayner G.S. Date July 9/91

Pendulum Type: Inverse/Normal
Pendulum Location: 5+68

Reading Table Condition: Good/Other
Explain

Reading Table Cleaned: Yes/Not Required
Bolted Connections Checked: Yes/No
Microlevel Readings Taken: Yes (attached)/No
Micrometer Readings Taken: Yes (attached)/No Bob has them

Wire Condition: Good/Tangled/Kinked/Other
Explain

Hanging Point of Normal Pendulum Wires in Grooves: Yes/No/Not Checked
Oil/Water Added to Dashpot: Yes/No/Not Checked

Rain Guard Condition: Good/Other
Is the Rain Guard Effective: Yes/No
Explain

(include probable source of bypassing leakage)
Rain Guard Cleaned: Yes/Not Required

Autocentering Readings Taken: Yes (attached)/No

Note any maintenance work performed or future repairs which are required:

Temporary ____ yrs
Permanent
Index

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Forward to: Supervisor
Dam Safety Program
Civil Works Department, A12-H14

Recorded by A. Morrow

refer to

Structure Rayner G.S. Date July 9/91

Pendulum Type: Inverse/Normal
Pendulum Location: 3+93

Reading Table Condition: Good/Other
Explain

Reading Table Cleaned: Yes/Not Required
Bolted Connections Checked: Yes/No
Microlevel Readings Taken: Yes (attached)/No
Micrometer Readings Taken: Yes (attached)/No BOB HAS THEM

Wire Condition: Good/Tangled/Kinked/Other
Explain SUSPENSION BAR BROKEN AT NECK DOWN. SEPARATED ~1/16". BROKE BEARING ON ADAPTER AT DECK LEVEL. WHAT HAPPENED? INSTALLED INVAR WIRE ASSEMBLY

Hanging Point of Normal Pendulum Wires in Grooves: Yes/No/Not Checked
Oil/Water Added to Dashpot: Yes/No/Not Checked DRAINED WATER OFF.

Rain Guard Condition: Good/Other
Is the Rain Guard Effective: Yes/No
Explain MINOR LEAKAGE INTO DASHPOT. DRAIN PERIODICALLY WHEN RESEVOIR GETS FULL.

(include probable source of bypassing leakage)
Rain Guard Cleaned: Yes/Not Required

Autocentering Readings Taken: Yes (attached)/No

Note any maintenance work performed or future repairs which are required:
VISUALLY MONITOR BRASS SUSPENSION BAR CONDITION AND MONITOR PENDULUM & INVAR READINGS CAREFULLY.

Temporary ____ yrs
Permanent
Index

Forward to: Supervisor
Dam Safety Program
Civil Works Department, A12-H14

Recorded by A. Morton

refer to

Structure RAINIER G.S. Date July 9/91

Pendulum Type: Inverse/Normal ✓
Pendulum Location: 3+47

Reading Table Condition: Good/Other ✓
Explain CALCIFICATION ON READING PINS.
- CLEANED WITH POCKET KNIFE.

Reading Table Cleaned: Yes/Not Required ✓
Bolted Connections Checked: Yes/No ✓
Microlevel Readings Taken: Yes (attached)/No ✓
Micrometer Readings Taken: Yes (attached)/No ✓ BOB HAS THEM

Wire Condition: Good/Tangled/Kinked/Other ✓
Explain

Hanging Point of Normal Pendulum Wires in Grooves: Yes/No/Not Checked ✓
Oil/Water Added to Dashpot: ~~Yes/No/Not Checked~~ ✓

Rain Guard Condition: Good/Other ✓
Is the Rain Guard Effective: Yes/No ✓
Explain

(include probable source of bypassing leakage)
Rain Guard Cleaned: Yes/Not Required ✓

Autocentering Readings Taken: Yes (attached)/No

Note any maintenance work performed or future repairs which are required:

Temporary ____ yrs
Permanent
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Forward to: Supervisor
Dam Safety Program
Civil Works Department, A12-H14

Recorded by A. Morton

refer to

Structure Rayner G-S. Date July 9/91

Pendulum Type: Inverse/Normal
Pendulum Location: 7+02

Reading Table Condition: Good/Other
Explain

Reading Table Cleaned: Yes/Not Required
Bolted Connections Checked: Yes/No
Microlevel Readings Taken: Yes (attached)/No
Micrometer Readings Taken: Yes (attached)/No Bob has them

Wire Condition: Good/Tangled/Kinked/Other
Explain

Hanging Point of Normal Pendulum Wires in Grooves: Yes/No/Not Checked
Oil/Water Added to Dashpot: Yes/No/Not Checked

Rain Guard Condition: Good/Other
Is the Rain Guard Effective: Yes/No
Explain

(include probable source of bypassing leakage)
Rain Guard Cleaned: Yes/Not Required

Autocentering Readings Taken: Yes (attached)/No

Note any maintenance work performed or future repairs which are required:

Temporary ____ yrs
Permanent ____
Index ____

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